

## IX.2 PERFORMANCE OF PROCEDURE

In this subsection the Resource Allocation Program is used to obtain sampling frequencies based on the demonstration case data. Three examples are considered. For each of the examples, the monitoring period (i.e., the time period for which the allocation is based) is assumed to be six months. The examples are:

- Case I. Use the first twelve months of data to obtain the initial source statistical descriptions. Determine the sampling frequencies for the following monitoring period (i.e., months 13 through 18).
- Case II. Use the data from months 13 through 18 to update the statistical description of the sources used in Case I. Determine the sampling frequencies for the following monitoring period (i.e., months 19 through 24).
- Case III. Obtain a revision of the sampling frequencies obtained in Case II, under the assumption that the sampling has to be interrupted in the middle of a sampling period due to a measurement of very poor water quality in a given river segment. (It is desired to sample two sources, which are expected to cause the poor quality, twice in the remainder of the monitoring period.)

This subsection is concluded with a comparison of the performance of the priority procedure developed in this report with a procedure that assigns sampling frequency on the basis of source flow.

### Case I

The source expected damage and probability of no violation obtained from the first 12 months of self-monitoring data is given in Table 9.3." The statistical description of the sources' constituents, and the

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\* Sources 5 and 21 are not included in this example due to insufficient data.

Table 9.3 DATA FOR CASE 1

SOURCE	PNV*	EXP. DAMAGE
1	.640361	1.824476
2	.366900	1.355373
3	.971105	.000615
4	.434765	3.428362
6	.966816	4.047932
7	.111617	3.517227
8	.006504	1.408283
9	.089683	7.781987
10	.072174	4.489711
11	.814871	2.719460
12	.138667	5.660459
13	.921435	3.340151
14	.964880	2.432983
15	.000060	2.813442
16	.981822	4.072095
17	.316116	4.018275
18	.034052	8.942007
19	.809288	5.787722
20	.696925	.388792
22	.117219	5.959835
23	.716378	4.220618
24	.992393	1.098906
25	.050330	3.744962
26	.388621	.601895
27	.000000	6.574204
28	.663566	6.318164
29	.883175	6.091859
30	.258403	1.090917

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\* Probability of no violation.

expected damage and probability of no violation for each constituent used to obtain the information in Table 9.3, is given in full in Appendix G.1.

In this example, the upper and lower bounds on the sampling frequencies are 0 and 3 respectively and the monitoring agency's budget is \$25,000. Table 9.4 gives the resulting priority list and Table 9.5 gives the sampling frequencies. Comparing these tables with Table 9.3, it is seen that those sources sampled most often and/or with highest priority have high expected damage and low probability of no violation.

## Case II

The assumptions and constraints for Case II are identical with those For Case I. The new expected damage and probability of violation For each source, based on the updated statistics is given in Table 9.6. The large effect of the update procedure on this data can be determined by comparing this table with Table 9.3. For example, the probability of no violation for source 20 went from 69.7% for Case I to 33.3% for Case II while the expected damage went from 0.387 to 0.737. The updated statistical description, the expected damage and the probability of no violation, for each constituent, is given in Appendix G.2.

Table 9.7 gives the priority list For this example, and Table 9.8 gives the sampling frequencies. There are large differences in some of the sampling frequencies for Cases I and II. For example, Source 6 was not sampled in Case 1 (Table 9.5) but was sampled two times in Case II (Table 9.8). Conversely, Source 11 was sampled three times in Case I but was not sampled in Case II. These changes are due to changes in the expected damage and probability of no violation for the sources.

Table 9.4 PRIORITY LIST: DEMONSTRATION PROJECT, CASE I

PRIORITY	SOURCE SAMPLED	MARGINAL RETURN X100	COST OF UNDETECTED VIOLATIONS	RESOURCES REQUIRED
1	18	1.52876276	95.09519	565.00
2	9	1.21510726	88.01112	1148.00
3	27	1.17396499	81.43692	1708.00
4	22	.93449891	76.17569	2271.00
5	12	.85837021	71.30014	2839.00
6	10	.73339251	67.13447	3407.00
7	25	.64697755	63.57410	3957.00
8	7	.55205745	60.45145	4523.00
9	15	.52535465	57.63818	5058.50
10	28	.37755728	55.51253	5621.50
11	4	.33937480	53.57470	6192.50
12	17	.29125971	50.82667	7136.00
13	28	.25053405	49.41616	7699.00
14	8	.23183490	48.01704	8302.50
15	23	.21376098	46.81998	8862.50
16	19	.20252984	45.71619	9407.50
17	28	.16624579	44.78023	9970.50
18	19	.16390498	43.88694	10515.50
19	23	.15313359	43.02940	11075.50
20	4	.14754831	42.18690	11646.50
21	30	.14709458	41.37788	12196.50
22	2	.14519234	40.51979	12787.50
23	19	.13264635	39.79687	13332.50
24	29	.12939626	39.06519	13882.50
25	12	.11902722	38.40911	14450.50
26	29	.11427958	37.78058	15000.50
27	1	.11159047	37.12442	15588.50
28	23	.10970148	36.51010	16148.50
29	22	.10954107	35.89338	16711.50
30	9	.10897437	35.25806	17294.50
31	29	.10092891	34.70295	17844.50
32	17	.09207177	33.83425	18788.00
33	11	.08902778	33.33080	19353.50
34	11	.07254612	32.92055	19919.00
35	1	.07145823	32.50038	20507.00
36	26	.06534158	32.13240	21070.00
37	4	.06414885	31.76611	21641.00
38	7	.06161888	31.41734	22207.00
39	11	.05911570	31.08304	22772.50
40	2	.05327107	30.76821	23363.50
41	10	.05293204	30.46756	23931.50
42	18	.05205818	30.17343	24496.50
43	13	.04788692	29.91101	25044.50
44	1	.04575910	29.64195	25632.50
45	13	.04412466	29.40014	26180.50
46	13	.04065799	29.17734	26728.50
47	30	.03800971	28.96828	27278.50
48	25	.03256254	28.78919	27828.50
49	17	.02910533	28.51458	28772.00

Table 9.5 SAMPLING FREQUENCIES: DEMONSTRATION PROJECT,  
CASE I

BUDGET 25000.00

SOURCE	MIN NO. SAMPLES REQUIRED	MAX NO. SAMPLES ALLOWED	TIMES SAMPLED	RESOURCES USED	COST OF UNDETECTED VIOLATIONS
1	0	3	2	1176.00	.74815
2	0	3	2	1182.00	.18245
3	0	3	0	.00	.00061
4	0	3	3	1713.00	.28174
6	0	3	0	.00	4.04793
7	0	3	2	1132.00	.04382
8	0	3	1	603.50	.00916
9	0	3	2	1166.00	.06259
10	0	3	2	1136.00	.02339
11	0	3	3	1696.50	1.47146
12	0	3	2	1136.00	.10884
13	0	3	0	.00	3.34015
14	0	3	0	.00	2.43298
15	0	3	1	535.50	.00017
16	0	3	0	.00	4.07209
17	0	3	2	1887.00	.40154
18	0	3	2	1130.00	.01037
19	0	3	3	1635.00	3.06773
20	0	3	0	.00	.38879
22	0	3	2	1126.00	.08189
23	0	3	3	1680.00	1.55168
24	0	3	0	.00	1.09891
25	0	3	1	550.00	.18859
26	0	3	1	563.00	.23391
27	0	3	1	560.00	.00000
28	0	3	3	1689.00	1.84605
29	0	3	3	1650.00	4.19653
30	0	3	1	550.00	.28190

TOTAL RESOURCES USED 24496.50

FINAL COST OF UNDETECTED VIOLATIONS 30.17343

Table 9.6 DATA FOR CASE II

SOURCE      PNV      EXP. DAMAGE

1	.696278	2.747735
2	.147692	1.701061
3	.979586	.000607
4	.531608	3.106736
6	.308329	3.762632
7	.111616	3.517227
8	.000191	1.513851
9	.032648	8.724413
10	.075379	5.623020
11	.938505	2.099448
12	.172521	5.397685
13	.743805	3.535545
14	.991440	2.267273
15	.000857	2.375780
16	.994912	4.120321
17	.316189	3.986394
18	.021793	9.106810
19	.974799	3.822610
20	.333279	7.736836
22	.232609	5.389093
23	.394030	4.628968
24	.922821	7.923437
25	.107414	3.571862
26	.484105	7.475020
27	.000000	6.675322
28	.615132	6.203027
29	.792984	6.596327
30	.163917	1.191331

\* Probability of no violation.

Table 9.7 PRIORITY LIST: DEMONSTRATION PROJECT, CASE II

PRIORITY	SOURCE SAMPLED	MARGINAL RETURN X100	COST OF UNDETECTED VIOLATIONS	RESOURCES REQUIRED
1	18	1.57669874	94.89202	565.00
2	9	1.44761255	86.45244	1148.00
3	27	1.19202173	79.77712	1708.00
4	10	.91534568	74.57796	2276.00
5	12	.78635007	70.11149	2844.00
6	22	.73455402	65.97595	3407.00
7	25	.57967152	62.78775	3957.00
8	7	.55205768	59.66311	4523.00
9	23	.50089604	56.85809	5083.00
10	6	.45182335	54.25559	5659.00
11	15	.44327629	51.88180	6194.50
12	28	.42404060	49.49449	6757.50
13	17	.28591804	46.76855	7701.00
14	28	.26084082	45.30002	8264.00
15	4	.25484597	43.84485	8835.00
16	8	.25079741	42.33129	9438.50
17	29	.24829064	40.96574	9988.50
18	2	.24531773	39.51591	10579.50
19	23	.19736782	38.41066	11139.50
20	29	.19688264	37.32780	11689.50
21	30	.18110030	35.33175	12239.50
22	22	.17086395	35.36979	12802.50
23	13	.16528967	34.46400	13350.50
24	28	.16045145	33.56066	13913.50
25	29	.15612484	32.70197	14463.50
26	1	.14192987	31.86742	15051.50
27	6	.13931040	31.06500	15627.50
28	12	.13566206	30.29444	16195.50
29	4	.13547814	29.52066	16766.50
30	13	.12294336	28.84713	17314.50
31	1	.09882264	28.26605	17902.50
32	13	.09144594	27.76493	18450.50
33	17	.09135259	26.90301	19394.00
34	20	.09047219	26.41175	19937.00
35	23	.07776874	25.97625	20497.00
36	4	.07202126	25.56500	21068.00
37	10	.06899758	25.17310	21636.00
38	1	.06880803	24.76851	22224.00
39	25	.06226493	24.42605	22774.00
40	7	.06161870	24.07729	23340.00
41	9	.04726118	23.80176	23923.00
42	26	.04352768	23.55669	24486.00
43	6	.04295348	23.30924	25062.00
44	22	.03974488	23.08552	25625.00
45	2	.03623144	22.87139	26216.00
46	18	.03435129	22.67725	26781.00
47	20	.03015250	22.51352	27324.00
48	30	.02968543	22.35026	27874.00
49	17	.02888465	22.07773	28817.50